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The Use of Percutaneous Transcatheter Embolization in Urology

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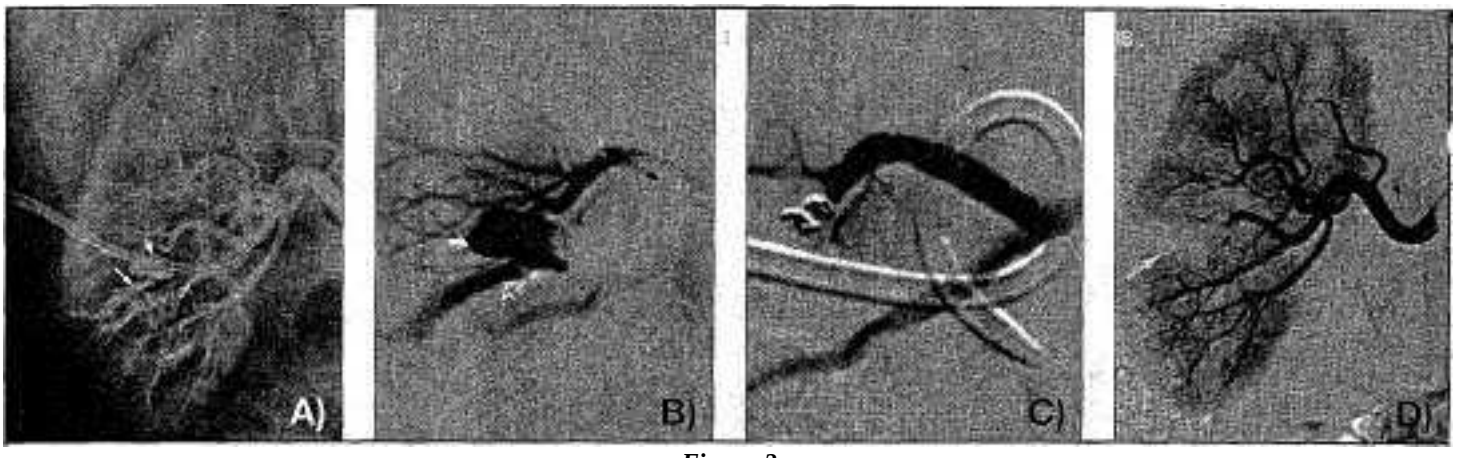

Figure 2

Bleeding post nephrostomy tube placement. A) Selective right renal angiogram shows a pseudoaneurysm (small arrow) 2° to tube placement with A-V communication (large arrow). B) Angiogram via microcatheter tip in lobar branch (arrow) shows vascular communication with tube tract (curved arrow) and venous fistula (open arrow). C) Immediately post coil "placement — no further extravasation. D) Final images show small area of infarction in the lobar distribution (arrow).

but AVFs are by far the most common entities.[87] AVFs may lead to deterioration of renal function, development of arterial hypertension, and even to cardiac decompensation due to high shunt volume. PAs alone may be asymptomatic, but carry a risk for spontaneous rupture which may subsequently lead to either an AVF or ACF.[88] PAs and ACFs while morphologically distinct from AVFs, are similar from clinical and therapeutic standpoints and occur with frequency in combination with AVF.[89,90] Spontaneous closure of biopsy-related AVFs has been shown to occur with a rate as high as 70 percent in both native and allograft kidneys.[85,91] TAE permits technical success in 70 to 95 percent of patients with persistent vascular abnormalities.[10,89] **Super selective placement of the catheter tips with the use of steering wires is essential to minimize loss of surrounding parenchyma. Microcoils are most frequently employed to occlude medium to small arteries, thus, allowing protection of vessels at the arteriolar level or the capillary bed and minimizing the risk of tissue necrosis.** Despite the use of super selective techniques, loss of 10 percent and up to 50 percent of surrounding renal parenchyma has been reported (Figure 2).[82,88,89]

Dorffner and colleagues reported their experience with transcatheter embolization in seven renal transplant recipients (six AVFs, one ACF and three PAs) who had undergone allograft biopsy and presented with hematuria or rapid loss of renal function.[92] Embolization was performed with coils and Lipiodol, PVA particles or Gelfoam were used as an adjunct to coils in four patients. They achieved angiographic success in five of seven patients (71 percent) or 10 of 12 vascular lesions (83 percent). Of the five angiographic successes, only three patients had resolution of their clinical symptoms. Despite angiographic success in the other two patients, renal deterioration continued in one patient despite a less than ten percent infarction of surrounding renal parenchyma, and acute hemorrhage occurred at the renal artery anastomosis following TAE in the other patient. In two of the seven angiographic unsuccessful patients, complete arterial occlusion developed requiring explantation.

Others have reported much better technical and clinical success rates. The UCSF group retrospectively detailed their experience with all post-biopsy renal allograft vascular injuries (21 patients with 11 isolated AVFs, four isolated PAs, four AVF+PAs, one dual synchronous AVFs, one AVF+4 PAs).[89] This group experienced a 95 percent technical success rate with amelioration of clinical signs and symptoms in 88 percent of evaluable patients and in 94 percent of patients

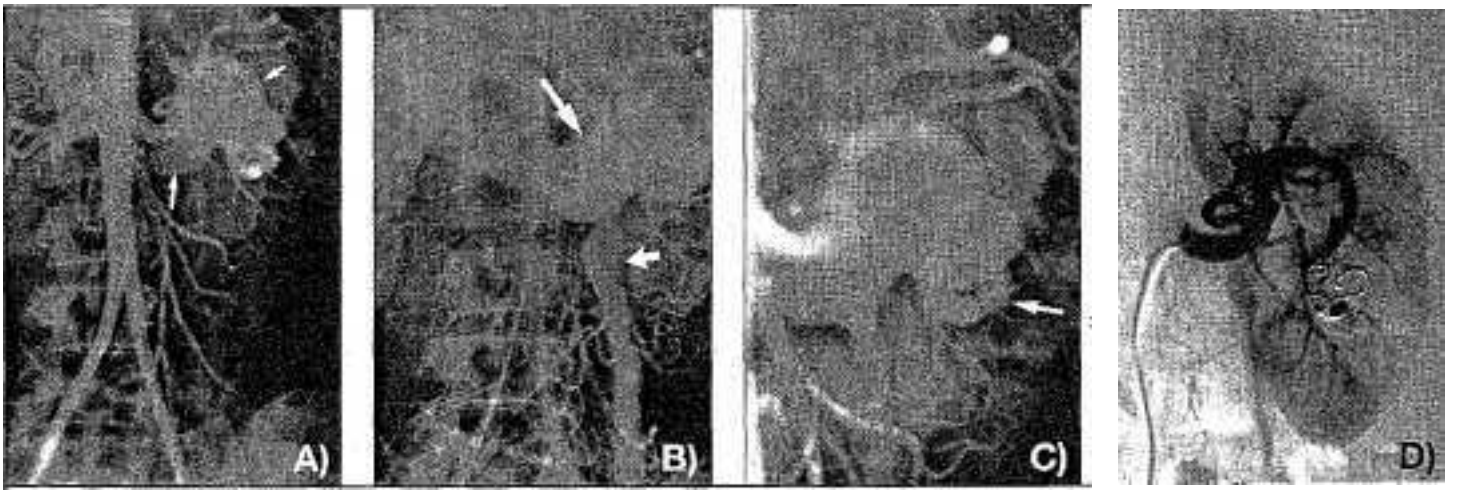

Figure 3

A 4 3-year-old female with a remote history of left flank trauma, now with left back pain. Ultrasound revealed a high flow A-V fistula in the left kidney. A) Aortogram shows hypertrophy of the left renal artery (small arrow) and vein (large arrow). B) Later images demonstrate enlargement of the renal vein (large arrow) and retrograde filling of the gonadal vein (small arrow). C) Close up view of the kidney showing lower pole A-V fistula (arrow). D) Post coil closure of the fistula note absence of the early venous outflow.

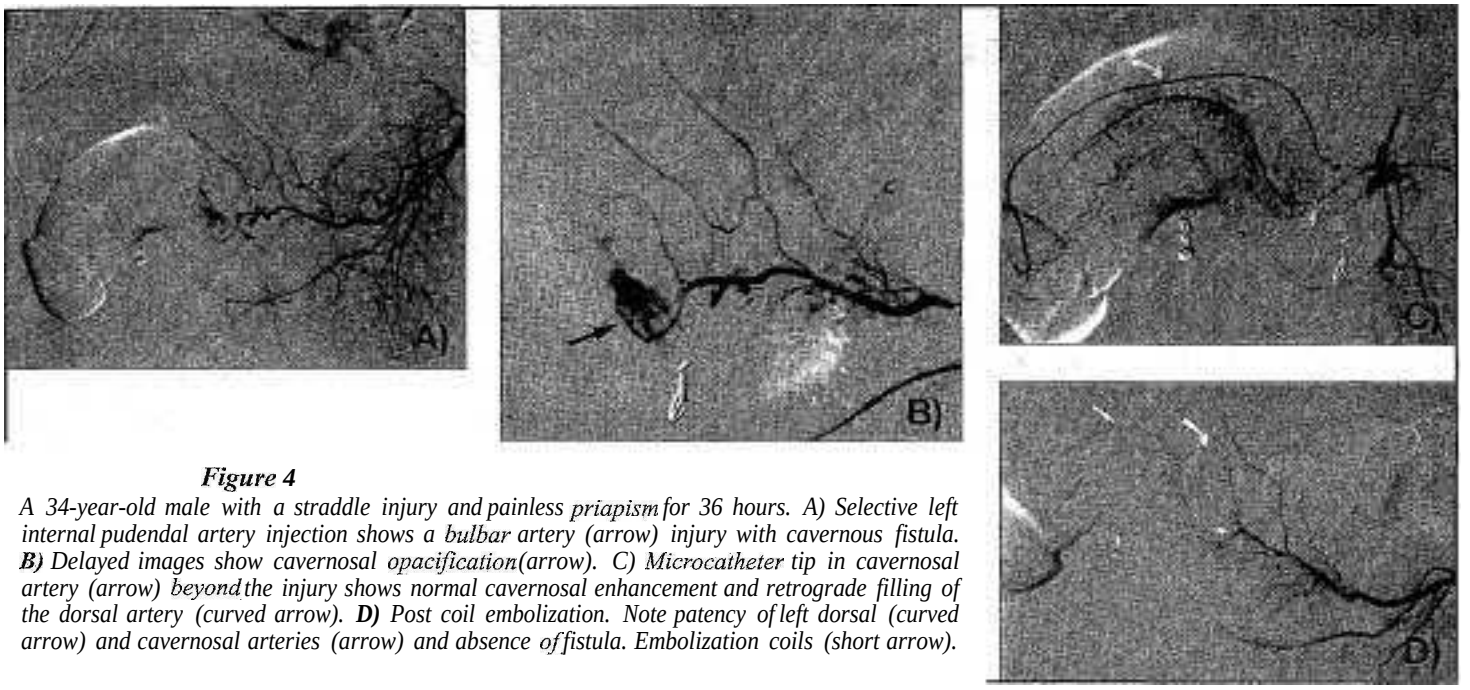

Figure 4

*A 34-year-old male with a straddle injury and painless priapism for 36 hours. A) Selective left internal pudendal artery injection shows a bulbar artery (arrow) injury with cavernous fistula. **B)** Delayed images show cavernosal opacification (arrow). C) Microcatheter tip in cavernosal artery (arrow) beyond the injury shows normal cavernosal enhancement and retrograde filling of the dorsal artery (curved arrow). **D)** Post coil embolization. Note patency of left dorsal (curved arrow) and cavernosal arteries (arrow) and absence of fistula. Embolization coils (short arrow).*

deemed a technical success. No patient in this group experienced allograft failure as a result of TAE.

Persistent Urine Leaks

Advanced pelvic neoplasms (cervical, uterine, ovarian, rectal, bladder) are frequently associated with urinary complications such as fistulas and ureteral obstruction. These are either as a direct consequence of the disease or as a result of treatment. Percutaneous or ureteral endoprosthesis drainage is frequently initiated, with the majority of patients who are initially drained internally requiring conversion to percutaneous external drainage.[93,94] Quality of life is often diminished due to the permanent external tube, repeated drain changes, recurrent urinary infections, or fistulization cutaneously or to other organs. The involved kidney is commonly non- or poorly-functioning at the time of disease diagnosis or when renal obstruction is subsequently discovered. Surgical nephrectomy in patients is often hazardous, even when performed laparoscopically.[95]

TAE of the kidney has been shown to be a safe means of treating patients with a poorly functioning kidney associated with debilitating ureteral obstruction or urinary fistulas.[96,97] De Baere and associates provided the single largest report of 20 patients (19 females and one male) with ureteral leaks or fistulas secondary to a variety of pelvic neoplasms.[98] Using ethanol, gel foam, and intravascular coils, they successfully interrupted arterial flow and removed the urinary drainage catheter the day after the procedure in 17 patients. Three patients required a second embolization where previously unseen lower pole or collateral arteries were successfully occluded with subsequent removal of the urinary drainage catheter. With the exception of well-managed post-infarction syndrome, there were no infectious complications and no patient had an increase in serum creatinine more than ten percent of the pre-embolization level. Long-term follow-up (median 14 months) found no return of the treated urologic problem.

Renal Trauma

Renal injury occurs in 1 to 15 percent of all trauma victims. The majority (>90 percent) are due to blunt mechanisms of injury.[99,100] The selective use of computed tomographic (CT) scan, careful clinical evaluation, and development of interventional radiology have permitted the evolution of a more conservative approach to renal trauma. Radiographic investigation of the kidney after abdominal trauma is indicated when 1) patients with penetrating injury demonstrate hematuria, 2) blunt abdominal trauma is associated with gross hematuria, 3) there is microscopic hematuria present and hypotension (systolic blood pressure <90mmHg at any time following injury), 4) microscopic hematuria is associated with significant injuries outside the urinary tract, or 5) children with blunt trauma and hematuria regardless of blood pressure or degree of hematuria.[101–103] The development of the American Association for the Surgery of Trauma (AAST) Organ Injury Scale for the Kidney (online at http://www.aast.org/iniury/injury.html) has been shown to accurately predict the necessity for surgery of the injured kidney with each grade being incrementally more significant in terms of morbidity or mortality.[104] CT can precisely delineate a renal laceration and its extent as well as the presence of a hematoma and its extent, the presence of urinary extravasation and the presence of devascularized segments of renal parenchyma.[105] Early and delayed enhanced scans through the kidney are necessary for a complete evaluation.[106]

Today there is little controversy about the conservative management of grade 1 and 2 injuries. However, the management of Grades 3, 4, and 5 injuries continues to be clinically challenging, balancing the increased incidence of nephrectomy in patients undergoing immediate surgery with the increased morbidity of patients who are closely observed.[99,107] When patients are taken immediately to surgery, nephrectomy rates correspond with the severity of renal injury (Grade III = 3 to 12.5 percent, Grade IV = 9 to 16.6 percent, and Grade V = 90 to 93 percent).[99,104]

The indications for renal exploration, namely an expanding, pulsatile, or uncontained retroperitoneal hematoma, suspected renal pedicle avulsion (Grade V injury),[107] persistent renal bleeding,[108] extracapsular extravasation, nonviable renal tissue[109] and incomplete injury staging,[110] have become increasingly less absolute, and more frequently exploration occurs during surgery for associated injuries.[111,112]

To avoid exploratory surgery for isolated renal trauma, TAE **has been increasingly employed for patients with Grade IV and V renal injuries.**[112] Hagiwara and colleagues prospectively reported

on 21 patients with Grade III or greater renal injuries and not having concomitant indications for abdominal exploration. All patients prospectively underwent angiography.[112] Angiographic findings were classified into four types (Table II). All patients with AAST Grade III injuries were found to have an angiographic type A or B injury. These types of injuries are not associated with significant arterial bleeding and do not require additional interventions. However, six often patients with AAST Grade IV injuries had angiographic type C injuries: and all five patients with AAST Grade V injuries had angiographic type C or D injuries which are associated With arterial bleeding. Angiographic type D injuries were managed conservatively in cases of main renal artery occlusion, or underwent emergency laparotomy when a main renal vein was injured. All eight patients with type C angiographic injuries were hemodynamically unstable prior to (shock index mean 1.08 ± 0.18) and at the time of angiography and had a large, extending retroperitoneal hematoma. Successful TAE was achieved in all eight patients and was followed by hemodynamic stabilization (shock index mean, 0.76 ± 0.11; $p<0.01$) avoiding surgical intervention. During follow-up from two months to seven years, all patients maintained normal renal function and remained normotensive. CT scan was performed monthly in all patients with AAST Grade IV or V injuries, until resolution of low density areas within the kidney was observed (6 to 12 months). No patient had evidence of an increase in the size of devitalized renal parenchyma after TAE and no patient experienced delayed hemorrhage, infection, or pseudoaneurysm formation (Figure 3).[109]

Employment of angiography and TAE in patients with AAST Grade IV or V renal injuries may avoid surgical exploration, stabilize the hemodynamically unstable patient, and decrease the nephrectomy incidence in highly selected patients. TAE has also been employed in the evaluation and treatment of symptomatic posttraumatic arteriovenous fistulas or persistent renal bleeding following blunt and penetrating trauma[113,114] or delayed bleeding following partial nephrectomy.[115,116]

Varicocele

Varicoceles are vascular lesions of the pampiniform plexus. Ten to 20 percent of the United States male population harbor this common vascular abnormality.[117] It is believed to be the most common identifiable abnormality in men being evaluated for infertility and has been cited as-a correctable source of chronic testalgia.[118,119] **Prophylactic repair of varicoceles in adolescence to preserve fertility has become increasingly recommended[120] with reversal of testicular atrophy after repair being well-documented.**[121] A prospective randomized comparison of intervention versus observation in 124 adolescent boys with Grade II to III varicoceles confirmed this point.[122] Surgical techniques to prevent the abnormal retrograde venous flow through the gonadal vein include retroperitoneal mass ligation of the gonadal vessels,[123] inguinal ligation,[124] subinguinal ligation,[125] and laparoscopic ligation.[126]

In 1978 Lima and colleagues[127] first described a retrograde radiographic technique of occluding internal spermatic veins. Since that time many authors have compared and contrasted this method of venous occlusion with the various surgical techniques. The clinical outcomes of both the prospective and retrospective studies have little commonality. As **a method of salvaging surgical failures, embolotherapy has gained greater popularity.**[128,129] **Retrograde venous embolization is** performed through either the jugular of femoral vein. The preferred embolic agents are coils (with or without adjuvant sclerosing agents), detachable balloons, or hot contrast material. The type of embolic agent does not seem to affect outcome.[16] Occlusion is usually accomplished at about the level of the superior pubic ramus and continued antegrade, taking care not to allow coil springs

TABLE II

Angiographic Classifications of Renal Injuries

Type A injury	Variable degrees of avascularity and heterogeneity in the accumulation; of contrast medium in the renal parenchyma or displacement of the renal arterial branches.
Type B injury	Disruption of renal artery branches.
Type C injury	Extravasation of contrast medium from a renal artery, or the presence of an arteriovenous fistula.
Type D injury	Complete occlusion of the main renal artery or injury to a main renal vein.

to extend into the renal vein or inferior vena cava. **The most common reason for technical failure is an inability to cannulate the internal spermatic vein or traverse a competent valve or venospasm.** The development of collateral channels is thought to be the primary reason for late recurrences.[16,130,131]

More recent attention has focused **on antegrade occlusion via cannulation of a scrotal vein**.[132] This technique is performed with local i subcutaneous anesthesia and the placement of a vascular cannula within the spermatic vein plexus below the external inguinal ring. Correct positioning of the cannula tip just beyond the internal inguinal ring is confirmed with contrast media. While the patient performs a Valsalva maneuver, the sclerosing agent is injected into the vein through the cannula and venography repeated to confirm occlusion. In a study from Rome by Mazzoni and colleagues prospectively enrolling 89 adolescents to undergo either retroperitoneal or antegrade sclerotherapy for scrotal varicoceles, they found the antegrade (Tauber) technique to have equivalent operative times to the retroperitoneal approach (mean time 30±5 min versus 20±7 min), shorter hospitalization (6 hours versus 18 hours), no de novo hydrocele formation (0 versus 2 percent), equivalent recurrence rates (4.5 versus 4.4 percent) and to be more economical ($ 105 versus $517).[133]

Intractable Hematuria/Pelvic Bleeding

Intractable hematuria can be the life-threatening consequence of a variety of neoplastic, inflammatory, and traumatic pelvic conditions. It can follow transurethral resection of a bladder tumor,[134] spontaneous rupture of a bladder hemangioma,[135] arise as the result of radiation[136] or cyclophosphamide induced cystitis,[137] follow traumatic or iatrogenic pelvic injuries,[138] or be secondary to pelvic and bladder malignancies.[139] Various methods of controlling bleeding in these situations have been promoted.[140] Unfortunately, the patients who seem to have the most refractory bleeding are often those who are also unfit for major surgical interventions or even cystectomy.

Control of intractable hematuria using muscle fragments to unilaterally embolize the internal iliac artery was first reported in 1974.[141] Since that time, multiple authors have reported the successful percutaneous occlusion of one or both iliac arteries with minimal risk and discomfort even in debilitated patients.[142,143] **Super selective catheterization of pelvic arteries has yielded control of hemorrhage results equal to open ligation of the hypogastric arteries or even cystectomy.**[139,144,145] The internal iliac artery is catheterized from either the ipsilateral or contralateral femoral artery, or if pelvic access is not available, through the left axillary artery. The **anterior division of the internal iliac artery is selectively embolized if bladder pathology is the isolated source of persistent bleeding, or is used to more selectively identify bleeding points in patients with pelvic trauma for highly selective embolization.** The superior and inferior vesical arteries can be catheterized to occlude very specific regions of the

bladder. **However, transpelvic collaterals are frequently abundant in the normal patient and often exaggerated in patients with long-standing pelvic tumors or inflammatory disease. It is frequently necessary to occlude the anterior division of both hypogastric arteries even when bleeding appears isolated to an ipsilateral wall of the bladder, thus, super selective occlusion of the vesical arteries is seldom beneficial. Embolization of the posterior division of the hypogastric artery must be avoided to prevent unwanted complications. Gluteal pain from the unintended occlusion of the superior gluteal artery is the most common complication.** Others have reported distal embolization of the lower limbs,[146] gangrene of the bladder,[147] and ischemic nerve damage.[145]

Jenkins and McIvor provided one of the few long-term outcome reports of patients undergoing internal iliac artery embolization for the control of severe hemorrhage due to pelvic malignant disease.[139] They successfully reduced transfusion requirements in their ten patients from a mean of 12 units per patient to 0 in five patients surviving a median of 3.8 months. Hayes and colleagues reported their successful control of intractable bleeding (mean 7,5 units per patient) through percutaneous internal iliac artery embolization in three patients with high grade transitional cell carcinoma of the bladder and one patient with metastatic bronchogenic carcinoma.[148] Patients experienced no complications and had complete or virtually complete cessation of bleeding and required no further transfusions until the time of their death from disease (mean 7.2 months). Massive pelvic and bladder hemorrhage following anterior pelvic rim fractures in four patients was successfully managed at Tulane University with TAE.[144] Upon delayed exploration of two patients to close bladder ruptures, the bladder appeared viable and healed promptly, supporting their theory that the collateral supply from contralateral sources is adequate to sustain tissue viability in the bladder. Within the same report, the group also details their successful management with TAE of two patients with bladder arteriovenous malformations, three patients with carcinoma of the bladder, and four patients with carcinoma of the cervix, all with intractable hematuria.

Penis

Venous Impotence

Erectile dysfunction from the failure to retain the blood within the corpora cavernosa is clinically demonstrated by the inability to increase intracorporal blood pressure above mean systolic blood pressure. Restricting venous-sinusoidal outflow is important for initiating and maintaining a rigid penile erection. Surgical treatments such as dorsal penile vein ligation[149,150] or resection[151] have been employed often with promising short term results (one month) but poor long-term benefits (25 to 60 percent success rate at >12 months).[152]

Veno-occlusive surgery generally removes veins from outside the corpora cavernosa. The poor long-term results of venous surgery for erectile dysfunction may in part be due to a reopening of ligated veins or an increase in venous return from the corpora cavernosa to other draining veins that are not easily ligated surgically. For this reason, **venoablation through the deep dorsal vein has recently been employed to improve long-term results in a highly selected group of men with isolated venous leak.**[153-157]

Nakata and colleagues introduced absolute ethanol through the deep dorsal penile vein in 23 patients.[158] All patients underwent pharmacocavernosometry and cavernosography. Patients were considered to have isolated venous leak impotence when the intracavernosal pressure did not get above 90 mmHg at a maximum infusion rate for tumescence of 150ml/min or for rigidity of 50ml/min, and color duplex Doppler ultrasound demonstrated sufficient arterial inflow. Absolute ethanol was introduced into the deep dorsal penile vein after surgical exposure and repeated until venography demonstrated no abnormal venous leakage from the corpora cavernosa. In this highly selected group, restoration of sufficient erections unaugmented by any other method, was reported by 87 percent of patients (self questionnaire) at one month and 78 percent long term (2 failures, 9 and 48 months, follow-up range from 6 to 50 months).

High Flow Priapism

Priapism is a pathological condition of a penile erection that persists beyond or is unrelated to sexual stimulation.[159] Non-ischemic, arterial priapism is caused by the laceration of the cavernosal artery or one of its branches and subsequent formation of an arteriocavernous fistula. It is most commonly associated with perineal trauma and usually presents as a prolonged, persistent, painless, partially or fully rigid erection. In the majority of cases, a cavernosal artery fistulous process can be demonstrated by duplex ultrasonography, and the diagnosis confirmed with an arterial blood gas pattern in the intracorporal blood.

Treatment remains somewhat controversial, and authors have reported no significant deleterious effects in men with this clinical entity for several years.[160] While conservative therapy including observation[161] or actual ligation of the fistulous vessel[162] has been offered, there has been increasing support for immediate super selective transarterial embolization.[163]

The aim of treatment is to temporarily occlude the cavernosal artery so that the fistulous laceration can heal. In theory, temporary occlusion allows cavernosal flow and, hence, erectile function to be restored after healing is complete.[164] Super selective internal pudendal angiography is performed to identify the fistula. Most commonly, autologous clot,[165] Gelfoam pledgets,[166,167] or N-butyl-cyanoacrylate[168] have then been employed as the temporary embolic agent. Recently, permanent microcoil embolization of the cavernosal artery was reported with successful restoration of normal erectile function (Figure 4).[169]

No single large series of patients treated for high flow priapism with super selective embolization has been reported. However, the combined success rate of all case reports is greater than 90 percent. Reported complications of internal pudendal artery occlusion have included penile gangrene, persistent impotence, gluteal ischemia, purulent cavernositis, recurrent priapism, perineal abscess or migration of the embolization material.[170]

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Study Questions Volume XXII Lesson 39

1. The choice of embolic material for use in therapeutic embolization is dependent on all of the following **except:**
   a) vessel size.
   b) catheter size.
   c) vascular access site.
   d) need for repeated embolization.
   e) whether permanent or temporary occlusion is required.

2. Which one of the following is the most commonly used permanent vascular occlusive agent?
   a) polyvinyl alcohol (PVA) particles
   b) macrocoils
   c) Avitene
   d) alcohol
   e) detachable balloons

3. Embolic agents resulting in temporary vascular occlusion include all of the following **except:**
   a) thrombin.
   b) autologous blood clot.
   c) Gelfoam torpedoes.
   d) Avitene.
   e) occlusion balloon catheter.

4. Renal artery embolization prior to radical nephrectomy for renal cell carcinoma may result in all of the following **except:**
   a) decreased operative blood loss.
   b) facilitation of renal dissection.
   c) palliation of symptoms.
   d) consistent improvement in survival.
   e) abatement of endocrine tumor activity.

5. Which one of the following is **not** characteristic of the post-infarction syndrome associated with renal artery embolization?
   a) flank pain persisting for 24 to 48 hours
   b) development of renal abscess
   c) significant pyrexia (104°F)
   d) paralytic ileus
   e) leukocytosis

6. Effective control of hypertension and proteinuria by percutaneous renal ablation can be achieved in what percentage of patients with ESRD?
   a) 20 percent
   b) 40 percent
   c) 60 percent
   d) 80 percent
   e) 100 percent

7. Which of the following is an indication for percutaneous transcatheter renal artery embolization?
   a) acutely bleeding angiomyolipoma
   b) gastrointestinal compression resulting from autosomal dominant polycystic kidney disease (ADPK)
   c) percutanous nephrostomy induced arteriovenous fistula
   d) poorly functioning kidney associated with ureteral obstruction
   e) all of the above

8. Embolization therapy for occlusion of internal spermatic veins in the treatment of varicoceles is most commonly performed:
   a) by antegrade cannulation of spermatic veins below the external inguinal ring.
   b) for chronic testalgia.
   c) as first line therapy for varicocele-induced infertility.
   d) to reverse testicular atrophy in adolescents.
   e) as salvage therapy for surgical failures.

9. Thromboembolic treatment of high-flow priapism should be accomplished by:
   a) temporary occlusion of the cavernosal artery.
   b) temporary occlusion of the deep dorsal vein.
   c) temporary occlusion of the pudendal artery.
   d) permanent occlusion of the pudendal artery.
   e) permanent occlusion of the deep dorsal vein.

10. A 70-year-old patient seven years post-radiotherapy has persistent gross hematuria refractory to all other therapeutic measures and is now requiring frequent blood transfusions and chronic hospital admissions. Prior to embolotherapy, the source of the bleeding is isolated to the left lateral wall of the bladder. In completing embolotherapy:
    a) super selective angioinfarction of the superior vesical artery should be sufficient to stop the hemorrhage.
    b) embolization of the posterior division of the hypogastric artery must be avoided.
    c) embolization of the anterior division of the hypogastric artery bilaterally must be avoided.
    d) selective embolization of the anterior division of the internal iliac artery will result in chronic gluteal pain.
    e) the chronic inflammation of long-standing pelvic tumors results in few significant pelvic collaterals.

Fill in answers on answer sheets provided.